REFINEMENT OF FINITE ELEMENT APPROXIMATIONS ON TETRAHEDRAL MESHES USING CHARMS

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Adaptive refinement of finite element approximations on tetrahedral meshes is generally considered to be a non-trivial task, since splitting individual finite elements needs to be done with much care to prevent significant deterioration of the shape quality of the refined meshes. State of the art refinement techniques proceed by selecting individual finite elements for refinement, and bisecting or octasecting them. Since the mesh at that point is no longer conforming, special steps need to be taken to restore the conformity [3]. Considerable complexity thus results, which makes it difficult to design (and even more importantly, to later maintain) adaptive tetrahedra-based simulation codes.

An adaptive refinement methodology, dubbed CHARMS (Conforming Hierarchical Adaptive Refinement MethodS), has recently been proposed by Krysl, Grinspun, and Schröder [1]. The methodology streamlines and simplifies mesh refinement, since conforming (compatible) meshes always result by construction. Moreover, the present approach is an instance of an extremely general methodology which has been shown to apply equally well in one, two, and three dimensions, and for large number of finite element types (triangles, quadrilaterals, hexahedra, or subdivision surfaces). The present work capitalizes on these conceptual developments to build a mesh refinement technique for tetrahedra. We adapt the element octasection based on the Kuhn triangulation of the cube to guarantee non-deteriorating shape quality for an arbitrary number of refinement levels [2]. Publications, examples of simulations, and pointers to other information are available at [4].

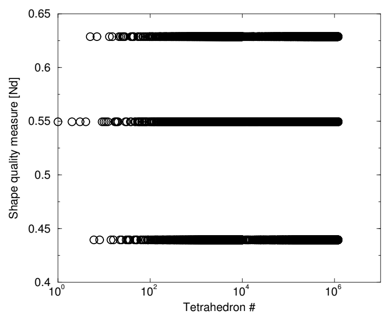

Figure 1: Shape quality measures from a 10-level uniform refinement of a random initial tetrahedron.

References

[1] P. Krysl, E. Grinspun, and P. Schröder. Natural hierarchical refinement for finite element methods. *International Journal for Numerical Methods in Engineering*, 2002. to appear.
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[3] D. N. Arnold and A. Mukherjee and L. Pouly Locally adapted tetrahedra meshes using bisection *SIAM Journal on Scientific Computing, 22 (2): 431-448*, 2001.
[4] P. Krysl. `http://hogwarts.ucsd.edu/~pkrysl/charms.html`